

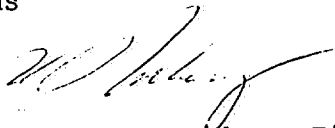
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Richmond, Virginia

To: . Mr. R. S. Mullins

Date: October 18, 1988

From: . W. L. Mokarry 

Subject: . Low Density Rods - Steam Residence Time Study

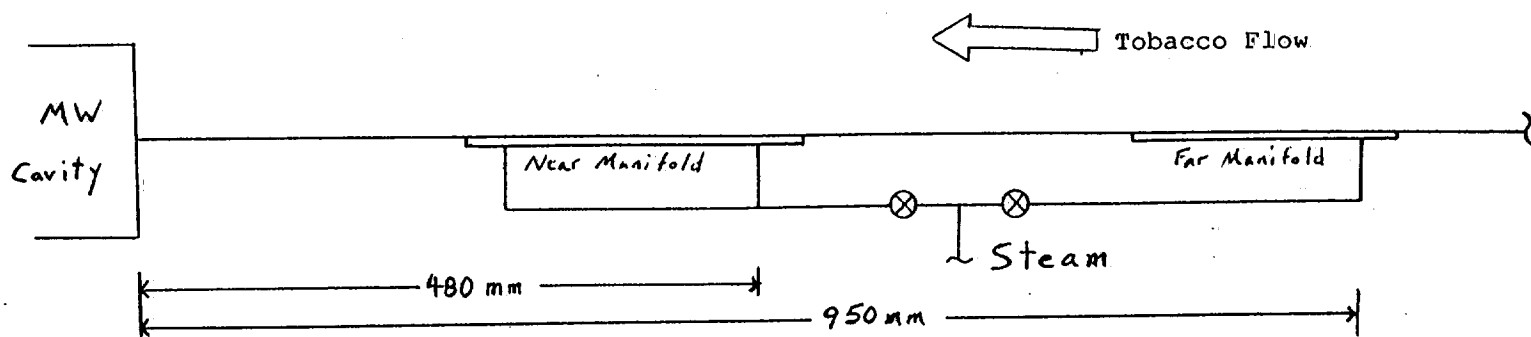
PURPOSE: To determine the effect of steam residence time on the physical quality of low density rod cigarettes. Steam residence time is defined as the length of time the filler is exposed to steam for binder reactivation before entering the microwave cavity.

CONCLUSIONS: Even at the lowest steam residence time (0.37 seconds), a good quality bonded rod was produced. For low density rods, firmness appears to be a function of tobacco weight and maker speed, but not steam residence time (over the range tested). Loose ends appear to be affected by steam residence time, as well as by cigarette weight and rod circumference. The circumference effect, however, is negative, with lower circumference values yielding greater loose ends fallout. These circumference and maker speed effects could indicate degradation of filler and/or bonds at the wrapper or tipper.

RECOMMENDATIONS: Tests should be run to study the effects of circumference variation on firmness and loose ends. A program should be initiated to determine the effect of the tipper on the quality of low density cigarettes. Also, since any relationship between maker speed and cigarette firmness would have implications for scale-up of the maker, this relationship should be further investigated.

PROCEDURE: The tobacco used in this study was blended, cased all lamina filler with a 6% add-on of a 2% undegraded Genu L200 pectin solution. Three cigarette parameters were varied during the test: tobacco weight, maker speed, and steam injection location. Two tobacco weights were run - low (575 mg) and high (650 mg). Three maker speeds were used - 650, 1000, and 1350 cpm. And two steam injection points were designed - near (480 mm from the microwave cavity) and far (950 mm from the microwave cavity).

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The above sketch shows the steam piping layout. Two valves were added to the steam piping to allow flow changes without stopping the maker. For the near location, steam is injected into a manifold via two injection ports. The further of these two points was chosen as the best representative value for the location at which the steam is present in sufficient quantities to begin binder reactivation. The far location also has steam injected into a manifold. However, only one injection port is used here. The location of the injection port is again used as the best estimate for the point at which enough steam is present to initiate binder reactivation.

The combinations of speed and distance yielded a range of residence times of 0.37 to 1.54 seconds (see Table 1). Three replications were made for each condition, and all conditions were randomized. Cigarettes were equilibrated and tested for firmness and loose ends.

RESULTS: Firmness and loose ends values are summarized in Table 1. When firmness data are plotted versus steam residence times (Figure 1), it appears that the residence time has an effect on firmness. However, if the residence time data are broken down to speed and distance parameters, a plot of firmness versus maker speed (Figure 2) yields no differences due to steam injection location. Step-wise multiple regression (equation shown in Figure 3) indicates that the factors affecting firmness are tobacco weight and maker speed¹. This is somewhat surprising, since previous analyses showed no firmness difference when maker speed was increased from 750 to 1000 cpm². However, a much larger range of speeds was examined in this study. Alternatively, the randomization of the test, with continual changes in speed over short periods of time, may have prevented the maker operating conditions from being optimized at each speed. Thus, the observed maker speed effect may be artificial.

Loose ends data, plotted in Figure 4, show a trend of increased steam residence time yielding lower tobacco fallout. When these data are plotted against maker speed with steam injection location contours (Figure 5), it is apparent that both location and speed affect loose ends results. Stepwise multiple regression (equation shown in Figure 6) indicates that steam residence time, cigarette weight, and circumference significantly affect loose ends fallout³. The overall regression is not especially good ($R^2 =$

¹ Lab Notebook 8651, pp 71 - 76.

² Douglas, S. Notebook 8709 pp 5 - 12.

³ Lab Notebook 8651, pp 77 - 82.

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0.722). One factor influencing this poor fit is the small range of loose ends values achieved.

The effect of circumference on loose ends is surprising in that the result is negatively correlated. That is, smaller circumference is seen to yield larger tobacco fallout. This is opposite of previous experience with standard cigarettes. A possible explanation for this reversal is that at the smaller circumferences, tobacco shreds or the bonds between the shreds are broken due to excess compression. Studies are planned to examine this hypothesis.

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TABLE 1
Steam Residence Times

<u>Distance from Microwave Cavity (mm)</u>	<u>Maker Speed (cpm)</u>	<u>Residence Time (sec)</u>
480	650	0.78
	1000	0.51
	1350	0.37
950	650	1.54
	1000	1.00
	1350	0.74

57 mm rods

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TABLE 2

Steam Residence Time Study
Firmness/Loose Ends Data

		Low Speed/Near Injection/Low Weight		

Filler Weight	mg	567	574	555
OV	%	11.90	12.12	12.43
Circumference	mm	24.89	24.80	24.80
Rod Density	g/cc	0.202	0.206	0.199
Maker Speed	cpm	650	650	650
Steam Residence Time	sec	0.78	0.78	0.78
Distance from Microwave	mm	480	480	480
Firmness	mm	3.02	2.90	2.93
Cigarette Weight	g/50 cigts	41.13	41.83	41.29
Loose Ends	g	0.15	0.16	0.16

		Low Speed/Near Injection/High Weight		

Filler Weight	mg	633	643	633
OV	%	12.19	12.32	12.24
Circumference	mm	24.86	24.82	24.97
Rod Density	g/cc	0.226	0.230	0.224
Maker Speed	cpm	650	650	650
Steam Residence Time	sec	0.78	0.78	0.78
Distance from Microwave	mm	480	480	480
Firmness	mm	2.29	2.11	2.28
Cigarette Weight	g/50 cigts	45.26	45.54	44.9
Loose Ends	g	0.14	0.10	0.10

		Medium Speed/Near Injection/Low Weight		

Filler Weight	mg	569	578	548
OV	%	12.30	12.27	12.10
Circumference	mm	24.86	24.65	24.88
Rod Density	g/cc	0.203	0.210	0.195
Maker Speed	cpm	1000	1000	1000
Steam Residence Time	sec	0.51	0.51	0.51
Distance from Microwave	mm	480	480	480
Firmness	mm	2.94	2.69	3.09
Cigarette Weight	g/50 cigts	41.51	41.78	40.55
Loose Ends	g	0.12	0.17	0.20

		Medium Speed/Near Injection/High Weight		

Filler Weight	mg	627	635	632
OV	%	12.29	12.16	12.33
Circumference	mm	24.84	24.92	24.94
Rod Density	g/cc	0.224	0.225	0.224
Maker Speed	cpm	1000	1000	1000
Steam Residence Time	sec	0.51	0.51	0.51
Distance from Microwave	mm	480	480	480
Firmness	mm	2.34	2.28	2.29
Cigarette Weight	g/50 cigts	45.04	44.96	44.63
Loose Ends	g	0.10	0.11	0.10

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Table 2
(continued)

High Speed/Near Injection/Low Weight				
		548	574	553
Filler Weight	mg			
OV	%	12.23	12.27	12.14
Circumference	mm	24.62	24.74	24.76
Rod Density	g/cc	0.199	0.207	0.199
Maker Speed	cpm	1350	1350	1350
Steam Residence Time	sec	0.37	0.37	0.37
Distance from Microwave	mm	480	480	480
Firmness	mm	3.21	3.25	3.03
Cigarette Weight	g/50 cigts	40.87	40.54	40.71
Loose Ends	g	0.22	0.26	0.15

High Speed/Near Injection/High Weight				
		644	632	636
Filler Weight	mg			
OV	%	12.19	12.11	12.16
Circumference	mm	24.90	24.60	24.86
Rod Density	g/cc	0.229	0.230	0.227
Maker Speed	cpm	1350	1350	1350
Steam Residence Time	sec	0.37	0.37	0.37
Distance from Microwave	mm	480	480	480
Firmness	mm	2.26	2.34	2.40
Cigarette Weight	g/50 cigts	44.41	45.16	45.06
Loose Ends	g	0.15	0.20	0.17

Low Speed/Far Injection/Low Weight				
		553	538	543
Filler Weight	mg			
OV	%	12.19	12.14	12.32
Circumference	mm	24.72	24.78	24.80
Rod Density	g/cc	0.200	0.193	0.195
Maker Speed	cpm	650	650	650
Steam Residence Time	sec	1.54	1.54	1.54
Distance from Microwave	mm	950	950	950
Firmness	mm	2.87	2.99	3.01
Cigarette Weight	g/50 cigts	40.97	40.99	40.66
Loose Ends	g	0.08	0.08	0.09

Low Speed/Far Injection/High Weight				
		649	637	648
Filler Weight	mg			
OV	%	12.24	12.36	12.06
Circumference	mm	24.79	24.82	24.81
Rod Density	g/cc	0.233	0.228	0.232
Maker Speed	cpm	650	650	650
Steam Residence Time	sec	1.54	1.54	1.54
Distance from Microwave	mm	950	950	950
Firmness	mm	2.12	2.21	2.02
Cigarette Weight	g/50 cigts	45.98	45.18	45.58
Loose Ends	g	0.08	0.06	0.06

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Table 2
(continued)

		Medium Speed/Far Injection/Low Weight		

Filler Weight	mg	567	563	565
OV	%	12.18	12.15	12.09
Circumference	mm	24.73	24.80	24.67
Rod Density	g/cc	0.204	0.202	0.205
Maker Speed	cpm	1000	1000	1000
Steam Residence Time	sec	1	1	1
Distance from Microwave	mm	950	950	950
Firmness	mm	2.87	2.93	2.80
Cigarette Weight	g/50 cigts	41.54	41.25	41.16
Loose Ends	g	0.13	0.13	0.10

		Medium Speed/Far Injection/High Weight		

Filler Weight	mg	647	646	631
OV	%	12.23	12.47	12.24
Circumference	mm	24.80	24.51	24.85
Rod Density	g/cc	0.232	0.237	0.225
Maker Speed	cpm	1000	1000	1000
Steam Residence Time	sec	1	1	1
Distance from Microwave	mm	950	950	950
Firmness	mm	2.17	2.15	2.21
Cigarette Weight	g/50 cigts	45.73	45.02	45.16
Loose Ends	g	0.12	0.10	0.08

		High Speed/Far Injection/Low Weight		

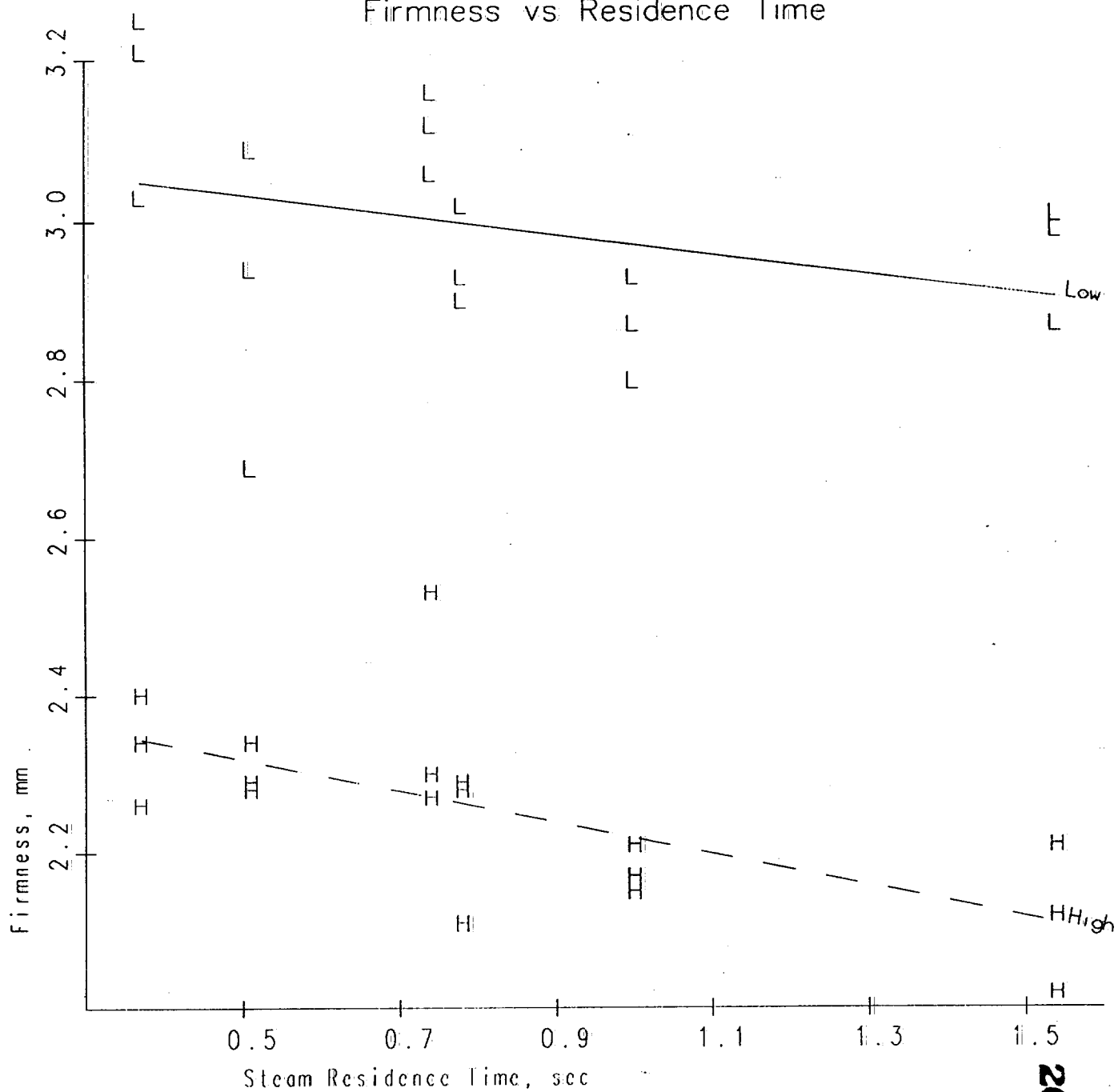
Filler Weight	mg	561	555	562
OV	%	12.20	12.22	12.15
Circumference	mm	24.78	24.49	24.61
Rod Density	g/cc	0.201	0.204	0.204
Maker Speed	cpm	1350	1350	1350
Steam Residence Time	sec	0.74	0.74	0.74
Distance from Microwave	mm	950	950	950
Firmness	mm	3.12	3.16	3.06
Cigarette Weight	g/50 cigts	41.04	41.12	40.75
Loose Ends	g	0.18	0.21	0.16

		High Speed/Far Injection/High Weight		

Filler Weight	mg	642	633	620
OV	%	12.29	12.14	12.25
Circumference	mm	24.90	24.64	24.76
Rod Density	g/cc	0.228	0.230	0.223
Maker Speed	cpm	1350	1350	1350
Steam Residence Time	sec	0.74	0.74	0.74
Distance from Microwave	mm	950	950	950
Firmness	mm	2.30	2.27	2.53
Cigarette Weight	g/50 cigts	45.07	45.13	44.67
Loose Ends	g	0.13	0.15	0.13

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FIGURE 1
Steam Residence Time Study
Firmness vs Residence Time

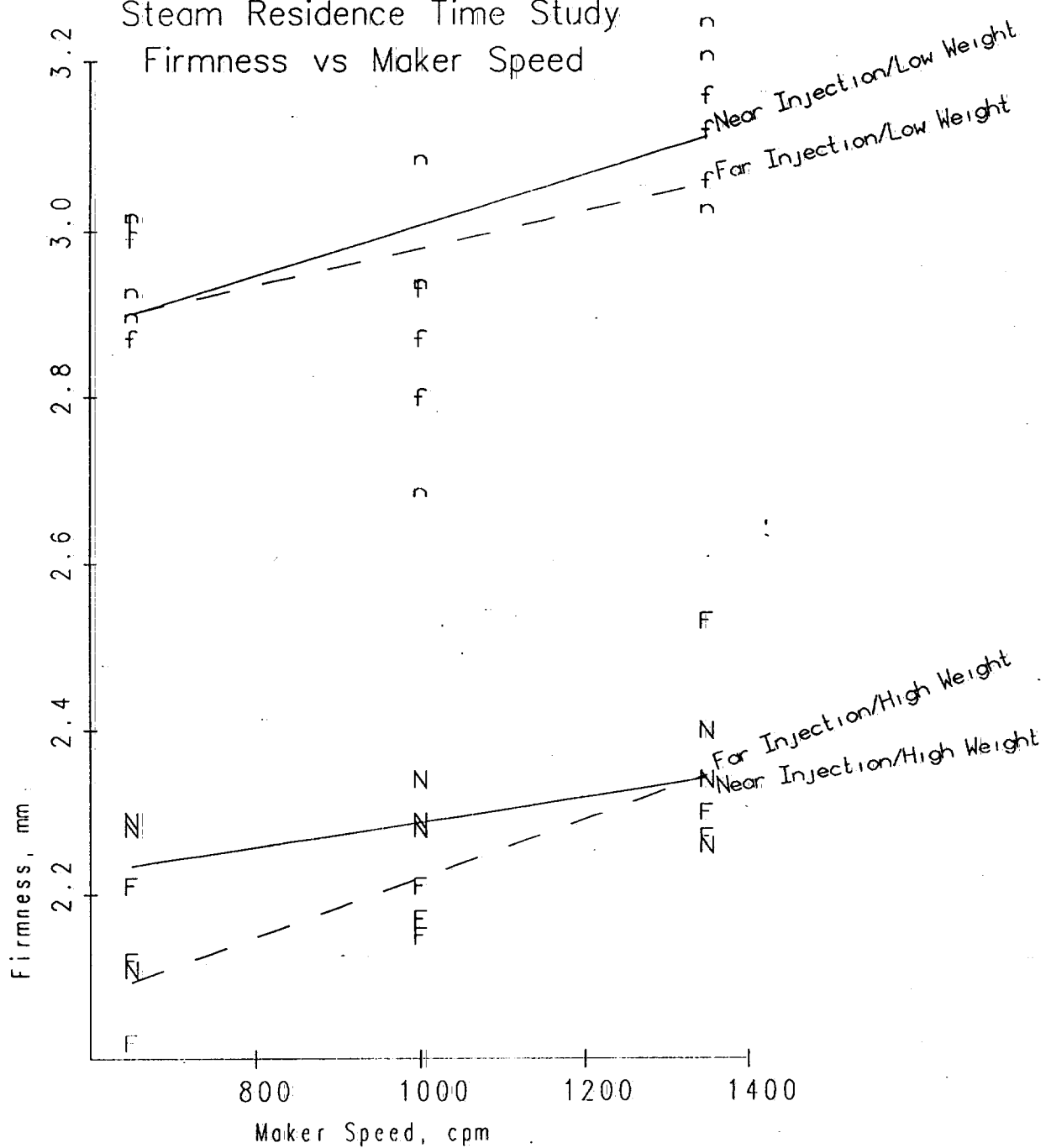


	N	R	SD	COE0	COE1
L=Low Weight	18	0.3363	0.1397	3.095	-0.1244
H=High Weight	18	0.6643	0.09037	2.419	-0.2003

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FIGURE 2

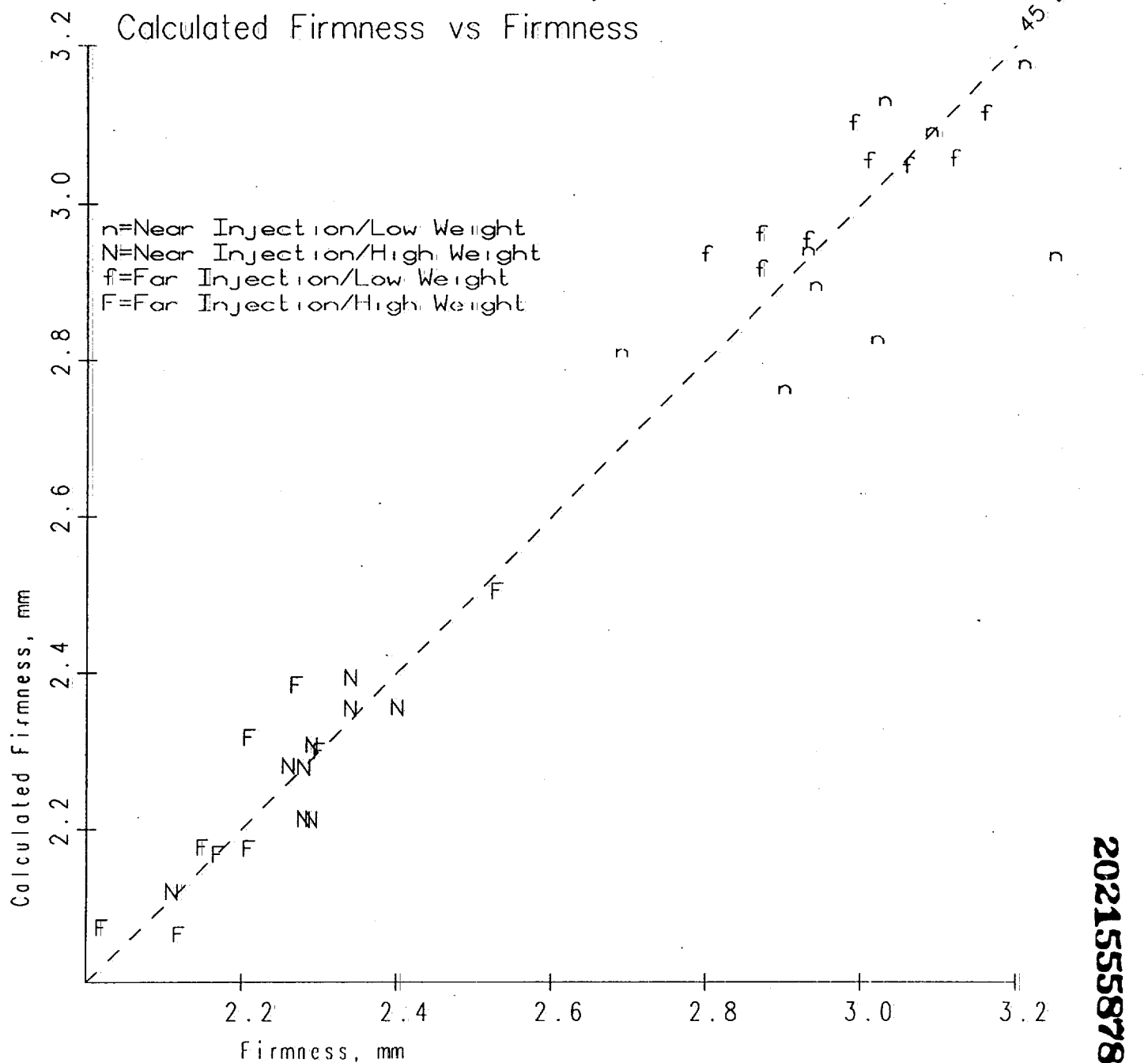
Steam Residence Time Study
Firmness vs Maker Speed



	N	R	SD	COE0	COE1
n=Near Injection/Low Weight	9	0.5446	0.1521	2.702	0.0003048
N=Near Injection/High Weight	9	0.581	0.06917	2.135	0.0001524
f=Far Injection/Low Weight	9	0.5574	0.108	2.755	0.0002238
F=Far Injection/High Weight	9	0.7593	0.09918	1.863	0.0003571

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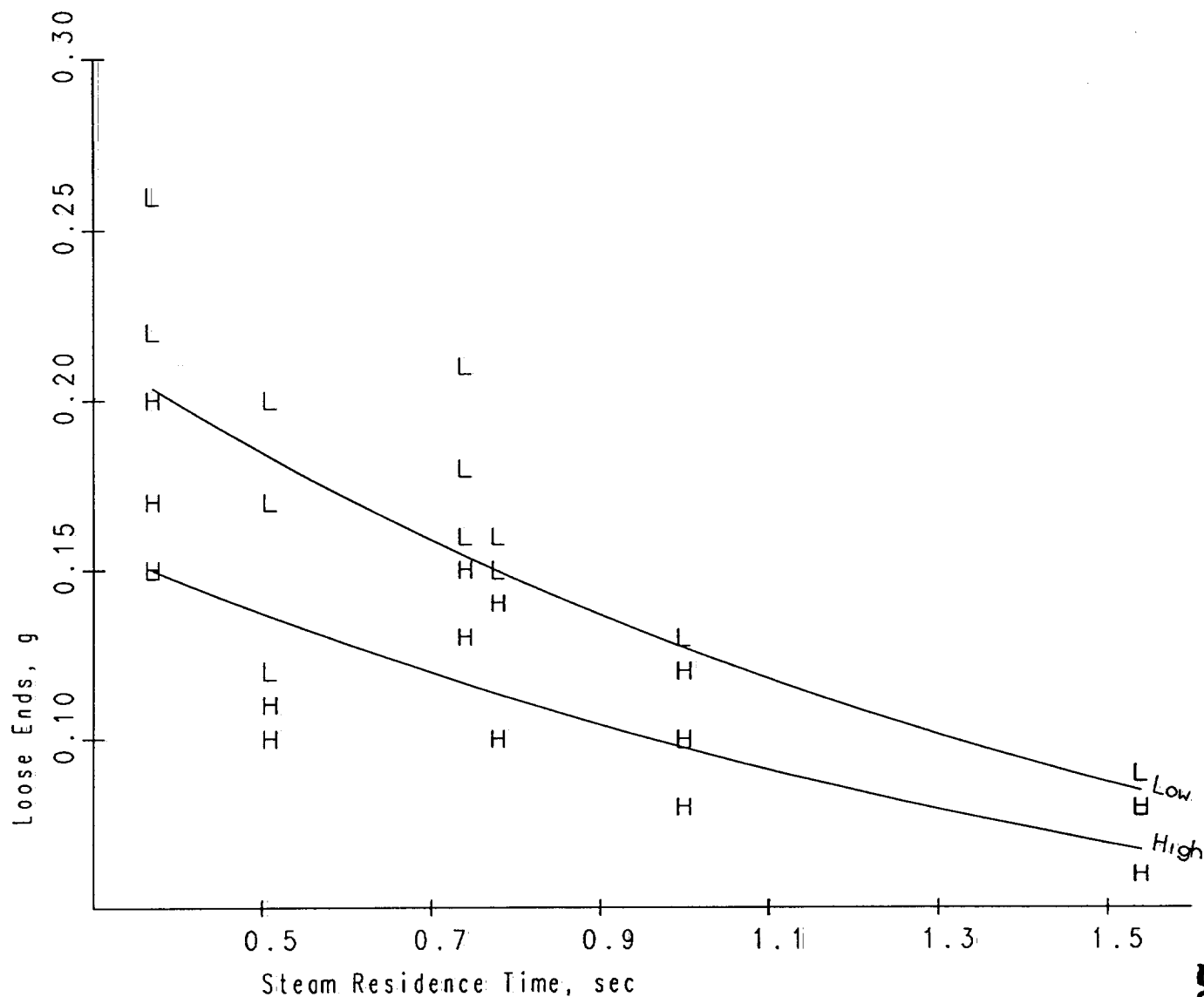
FIGURE 3
Steam Residence Time Study
Calculated Firmness vs Firmness



$$\begin{aligned} \text{Calculated Firmness} &= 7.9809 - .0009363(\text{Tobacco Weight}) \\ &\quad + 0.000245(\text{Maker Speed}) \\ R^2 &= 0.949 \quad SD = 0.9219 \end{aligned}$$

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FIGURE 4
Steam Residence Time Study
Loose Ends vs Residence Time



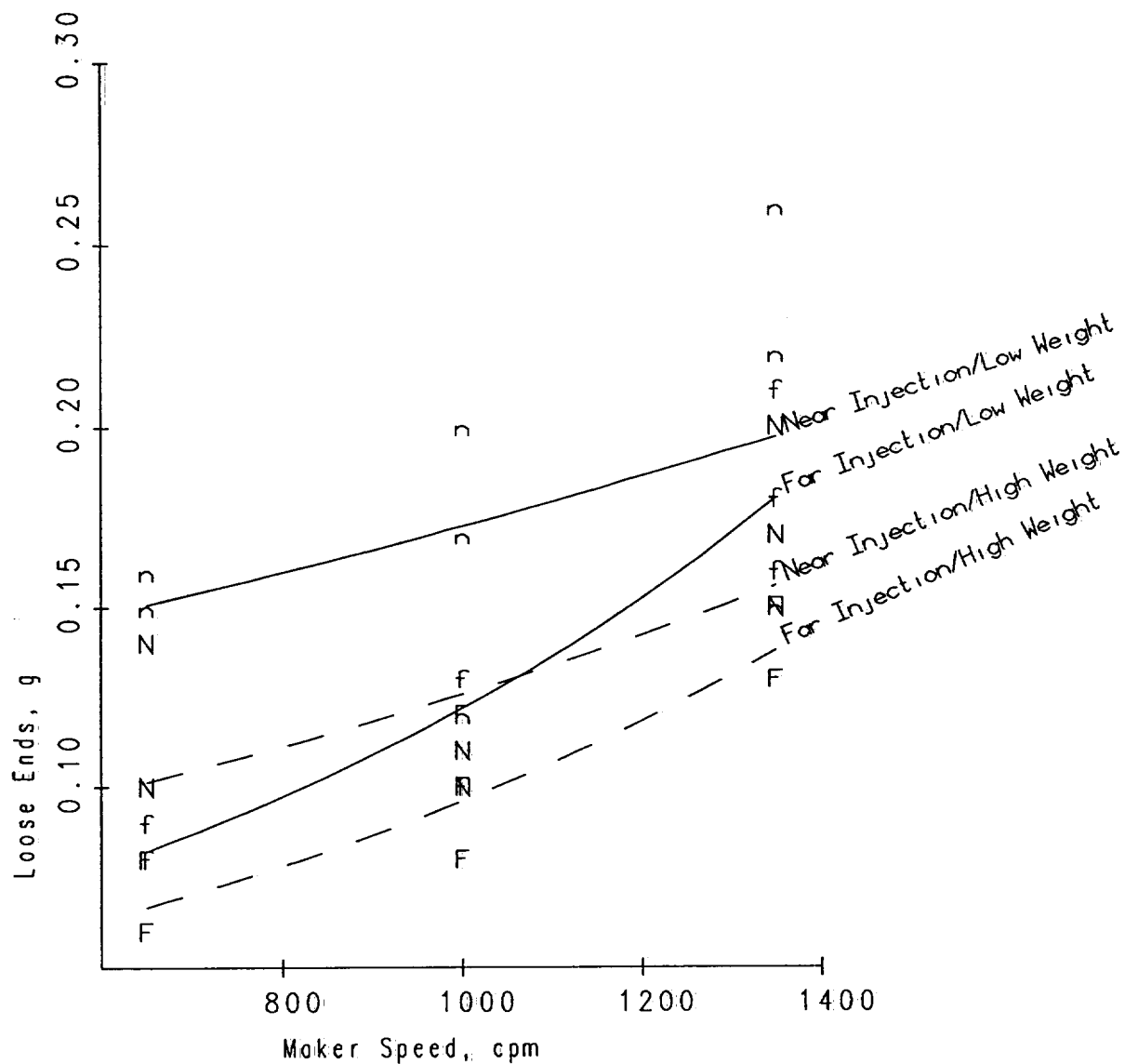
	N	R	SD	LSD	INT	SLOPE
L=Low Weight	18	0.851	0.1853	0.03029	-1.315	-0.7488
H=High Weight	18	0.808	0.2	0.02416	-1.644	-0.6842

LN Y= INTI + SLOPE#X.

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FIGURE 5
Steam Residence Time Study
Loose Ends vs Maker Speed

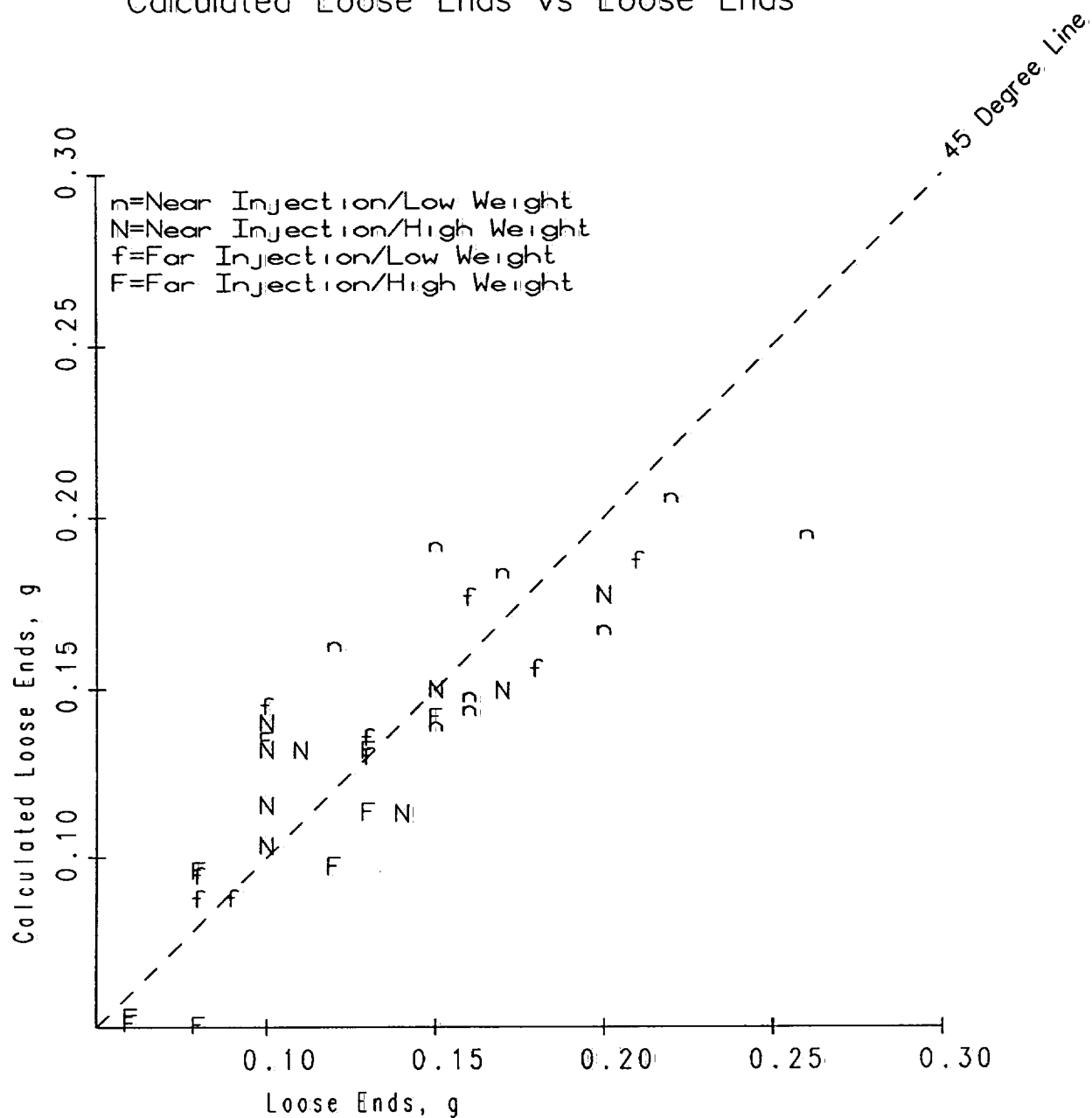


	N	R	SD	LSD	INT	SLOPE
n=Near Injection/Low Weight	9	0.4996	0.2151	0.03603	-2.141	0.0003828
N Near Injection/High Weight	9	0.695	0.2064	0.0256	-2.689	0.0006156
f=Far Injection/Low Weight	9	0.9523	0.1162	0.01572	-3.225	0.00112
F Far Injection/High Weight	9	0.9145	0.1485	0.01315	-3.378	0.001036
LN Y= INT + SLOPE#X						

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FIGURE 6
Steam Residence Time Study
Calculated Loose Ends vs Loose Ends



$$\begin{aligned} \text{Calculated Loose Ends} &= 3.2438 - 0.08569(\text{Steam Residence Time}) \\ &\quad - 0.00728(\text{Cigarette Weight}) - 0.11(\text{Circumference}) \\ R^2 &= 0.7223 \quad SD = 0.02603 \end{aligned}$$

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